MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY

DARPA/TTO PROGRAM
IR BINARY OPTICS

SEMIANNUAL TECHNICAL SUMMARY REPORT
TO THE
DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

1 JULY — 31 DECEMBER 1985

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LEXINGTON MASSACHUSETTS

ABSTRACT

This report describes the work performed at Lincoln Laboratory on IR Binary Optics under the sponsorship of DARPA/TTO during the period 1 July through 31 December 1985.

LIST OF ILLUSTRATIONS

3. BINARY LASER TELESCOPE

A six-inch primary CO_2 laser telescope, with a 5° aberration corrected FOV, is one of our main research efforts. The technology acquired in this effort could be applied to large space based segmented planar optical apertures and could be used to develop an appropriate embossing technology.

A prototype telescope that can replace the current diamond turned Ritchey-Chretien telescope in our laser radar test bed is under design. In a previous report, we discussed how we placed a lens transfer function on a spatial frequency carrier in the evanescent EM domain. We tested these diffractive lenses and measured diffraction efficiencies as high as 97 percent. The drawback of this approach, however, is the strong efficiency dependence on polarization. Most laser radars, use linearly polarized sources but generate circularly polarized light in the monostatic transmitter. Multilevel binary structures such as shown in Figure 1 can, with only three levels, achieve a diffraction efficiency as high as 90 percent in both polarizations. Therefore, we are now concentrating our efforts on multilevel structures for both laser radar and broadband telescope applications.

4. DIFFRACTIVE WIDEBAND TELESCOPES

Wideband light-weight diffractive infrared telescopes have many applications in FLIR imaging and throw-away optical systems. In order to operate efficiently over a large (>10 percent) bandwidth and with low aberrations, one must operate close to the optical axis. The high spatial frequency carrier approach that sustained near perfect diffraction efficiency in laser telescopes is not feasible here. Our approach has been to build asymmetry into the binary structures by using a multimask approach. With two masks (3 levels) 90 percent diffraction efficiency is feasible. With asymmetric relief profiles, close on-axis planar telescopes and frequency bandwidths in excess of 10 percent appear feasible. Two different mask designs are being tested, one three-level on-axis planar lens, and one three-level off-axis design.

We are designing the telescopes and the appropriate relief structures in collaboration with the University of Rochester and the University of Virginia. Professor Morris of Rochester and his PhD student are calculating the layout and feasible aberration corrections.

5. MODULAR LASER SOURCES

During the past six months we tested the coherent beam addition concept on modular infrared HeNe lasers and on linear arrays of monolithic GaAs lasers. The far-field pattern of the coherent sum (see Figure 2) is virtually indistinguishable from a single laser element, and no far-field sidelobes are generated in the summing process. We are studying cavity feedback and phase locking mechanisms that make coherent addition such a stable process. During FY86 we will test coherent addition on custom designed uncoupled GaAs laser arrays and optimize external cavity designs for maximum laser power output.

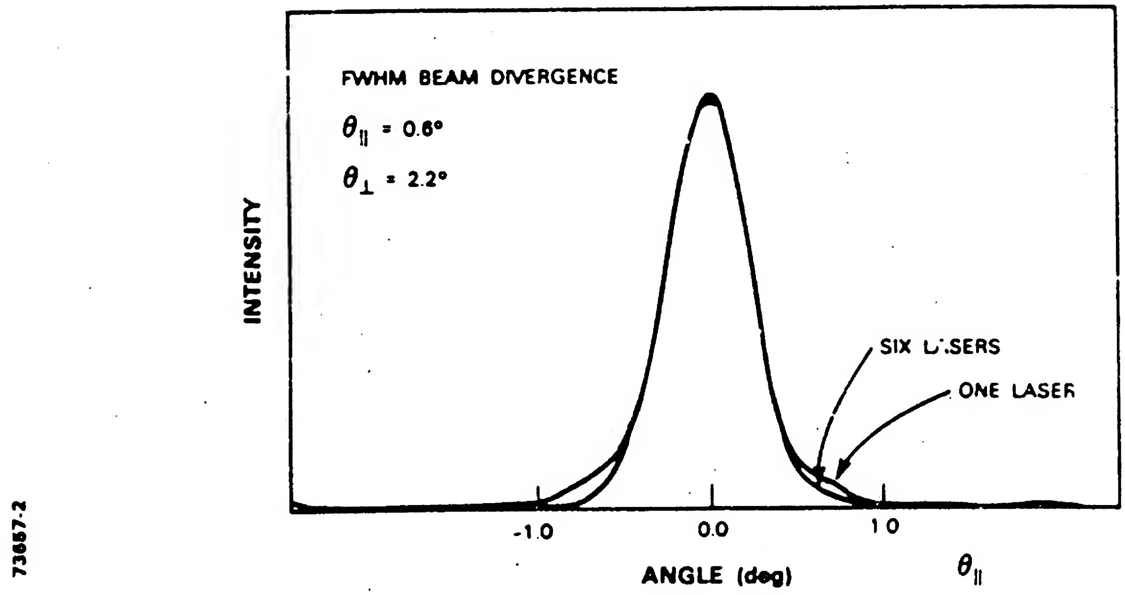

Figure 2. Far field sum of six coherently added GaAs lasers.

6. ELECTRON-GRATING LASERS

In September 1985 we set up a laboratory and started a research effort to study the interactions of electron beams with metallic gratings to generate tunable coherent light (see Figure 3). Tunable coherent light can be generated by exploiting the Salisbury effect (i.e., when an electron interacts with a conducting grating at a slant angle), by chirping the grating with a rate equal to the electron's Bremstrahlung rate, and by placing the grating structure inside a laser cavity. We have already observed tunable incoherent infrared radiation with harmonics throughout the visible spectrum from 2400 lines/mm gratings and 40 KeV electrons. With an optical cavity we will provide feedback to bunch electrons and to generate frequency coherence. We are also upgrading the system to higher e-beam power levels and to improved vacuum levels ($>10^{-8}$ Torr). The new system will be installed in February 1986.

Continued research on electron-grating lasers will establish the feasibility of one-octave tunable frequency lasers in the visible and the infrared. Sources like these will have applications in laser radars, jammers, and other optical systems.

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